

CONNECTED AND AUTOMATED VEHICLE PROGRAM STRATEGIC PLAN



2017

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Introduction

Purpose of the Plan

For over a decade, the Michigan Department of Transportation (MDOT) has been a leader on the world stage in advancing Connected and Automated Vehicle (CAV) technologies, leveraging its unique position as the home to the U.S. automotive industry, as well as departmental expertise in Intelligent Transportation Systems (ITS). The CAV industry is changing rapidly and continuously. As such, this strategic plan offers an opportunity to adapt to this change – to articulate the program mission, vision and goals, to re-evaluate strategies in the current industry environment, to validate or modify existing and planned initiatives, and finally to identify gaps and opportunities for initiatives to support goal achievement. This plan is not a beginning point, but instead is intended to serve as a waypoint in the course of a mature program to ensure it stays relevant and true to mission.

Scope of the Plan

This plan is referred to as a **Connected and Automated** Vehicle strategic plan, encompassing the department's initiative to support and implement emerging transportation technologies. MDOT views Connected Vehicle (CV) technology as an enabling technology for Automated Vehicles (AV), and thus sees actions supporting CV technology development and deployment as also supportive of future AV operation on state roadways. For the purposes of this document, "CAV" refers broadly to emerging transportation technologies, while "CV" refers specifically to strategies or tactical actions related to connected vehicle technology.

Plan Organization

This document is organized into the following sections:

- **Section 2** provides an overview of CAV technology.
- **Section 3** is a summary of the history of CAV development in Michigan, including Michigan's current position on the global stage.
- **Section 4** presents MDOT's CAV program mission and vision statements, the program goals, and the strategies outlined to achieve them.
- **Section 5** outlines the current tactical actions (including deployment activities/pilots, programmatic support activities, and outreach and industry leadership) being undertaken by MDOT to achieve the program goals.
- **Section 6** evaluates the strategic alignment between current tactical actions and outlined strategies, identifies gap areas, and presents recommended additional actions.
- **Section 7** highlights funding mechanisms and opportunities to support further development of the program.

Understanding Connected and Automated Vehicle Technology

Connected vehicle (CV) technologies enable all types of vehicles, roadways, other infrastructure, and mobile devices to all communicate and share vital transportation information. The primary communications technologies used to support CV applications is dedicated short-range communications (DSRC), which is similar to Wi-Fi and cellular. Many vehicles today are already “connected” through cellular technology. DSRC provides for fast, secure, and reliable communications, and is not vulnerable to interference which is necessary for many CAV applications.

Automated vehicles (AV) can detect their surroundings using a variety of techniques such as radar, GPS, and cameras. Advanced control systems on the vehicle interpret the detection data to identify appropriate navigation paths, as well as obstacles and signing and stripping. Automated cars have control systems that are capable of analyzing sensory data to distinguish between different vehicles on the road as well as the presence of bikes, pedestrians and obstacles.

It is fully expected that both vehicle connectivity and autonomy will work to together on future connected automated vehicles (CAV) and that the technologies will be integrated and synonymous. Connected automated technology allows vehicles to “talk to” each other, the roads they use, and even to pedestrians and cyclist who have mobile devices while driving safely. Using wireless technologies, this communication supports a range of applications that focus on safety, mobility and environmental benefits.

The advent of CAV’s along with the supporting technology and the ability to leverage available data will, in time, dramatically impact the roles and

responsibilities of transportation agencies who will need to find ways to be smarter about the use of their transportation facilities and services. CAV technologies represent a significant opportunity for Michigan to address fundamental transportation safety, mobility and environmental challenges faced by travelers and transportation systems managers alike in new and innovative ways.

According to the NHTSA, in 2015 there were more than 35,000 people killed in vehicle crashes in the United States. Michigan lost 963 to traffic accidents in 2015. According to the USDOT connected automated vehicles provide the means to potentially address about 80 percent of all-vehicle target crashes; 80 percent of all light-vehicle target crashes; and 70 percent of all heavy-truck target crashes annually. Through the use of CAV technology, alerts will warn travelers of emerging dangerous situations and provide them guidance to avert crashes. As an example, someday motorists will be automatically warned that they are approaching a work zone or some other lane closure at an unsafe speed and need to slow down and switch lanes via an in-vehicle device. This is just one of the many CAV safety applications that are being

developed, tested, and deployed in pilot programs in Michigan that will soon make the roads safer for travelers.

Increased mobility is another benefit that CAV technology offers. According to the 2015 Urban Mobility Scorecard published by Texas A&M Transportation Institute, traffic congestion in the United States caused drivers to waste 3.1 billion gallons of fuel and spend nearly 7 billion extra hours in traffic which equates to 42 hours per rush-hour commuter. These delays costs travelers \$160 billion in lost productivity and wasted fuel nationally. Detroit and Grand Rapids, Michigan are consistently ranked within the top 15 most congested cities in the nation when compared to cities of similar size. CAV technology provides transportation agencies the ability to maximize efficiency through real-time management of traffic, transit and parking operations. Those responsible for managing transportation systems can use the data generated by vehicles, by sensors imbedded in the infrastructure, and by mobile devices such as smart-phones to keep traffic flowing smoothly. Further, mobility applications will enable travelers to plan the most efficient and time-saving commute.

Emissions from vehicles are the single largest human-made source of carbon dioxide, nitrogen oxides, and methane. Vehicles that are stationary, idling, and traveling in a stop-and-go pattern due to congestion emit more greenhouse gases than those traveling in free-flow conditions. CAV technologies enables the capture, processing and distribution of real-time data that can be used to support more environmentally friendly operational decisions, both on the part of transportation system managers and the individual travelers. As an example, an eco-friendly application that adjusts traffic signals to help make fewer stops and starts when driving, would reduce delay and therefore decrease air pollution. Another application would give priority to transit vehicles at intersections, which would increase the number of people passing through an intersection, help transit vehicles adhere

to their schedules, and make public transportation more appealing.

According to United States Department of Transportation, it is anticipated that further deployment of CAV technologies will occur over the next 20-years as existing infrastructure systems are replaced or upgraded. It is anticipated that by 2040 that up to 80 percent of the intersections in the United States may connect to vehicles, while it is estimated that 90 percent of light vehicles will be sharing information with other vehicles and with the roads they use. A number of factors will impact what is expected to be an all-encompassing deployment of such technologies:

- The full commitment of the automotive and truck industries to implement the technology, in response to anticipated rulemaking actions by the National Highway Traffic Safety Administration (NHTSA) and in partnership with transportation agencies;
- State, local and regional agencies willingness and ability to deploy roadside equipment;
- Ensuring that possible sharing with other wireless users of the radio-frequency spectrum will not adversely affect the technologies performance;
- Developing technical standards to ensure nationwide interoperability;
- Developing and managing data security and addressing public concerns related to privacy;
- Ensuring that drivers respond appropriately to warning messages; and
- Addressing the uncertainties related to potential liability issues.

Work in Michigan is underway on many fronts to help understand and advance these factors.

The Technology behind Michigan's CAV Efforts

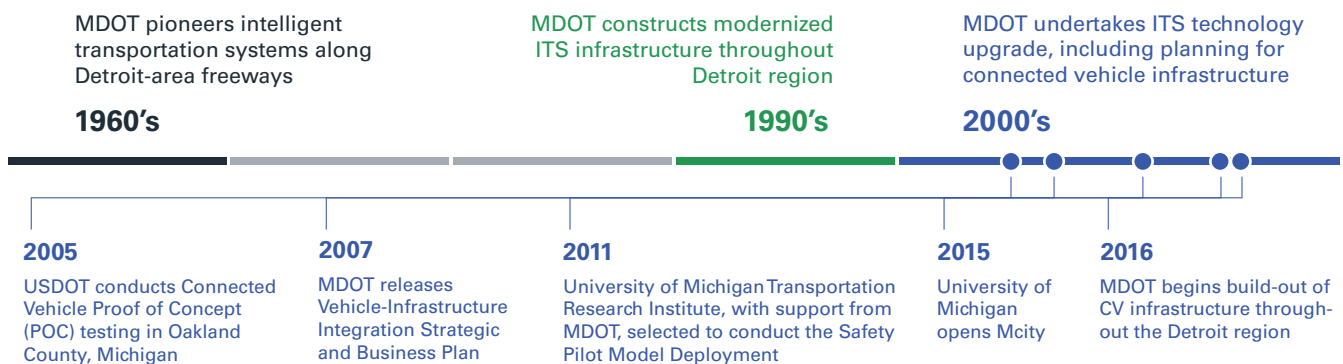
Vehicle conductivity relies on transmitting and receiving data from the roadside and other vehicles. As such there is a need to collect and provide accurate and timely data to vehicles when needed. To do so Michigan DOT is already studying and implementing modern proven supporting technologies:

A number of key technology components define the connected vehicle ecosystem, including:

- **Roadside Unit (RSU)** — Devices that send messages to, and receives messages from, nearby vehicles. The RSU operates from a fixed position or a portable device, and includes a processor, data storage and communications capabilities on a secure channel with other equipped vehicles. RSUs use Dedicated Short Range Communications (DSRC) or other alternative wireless communications technologies.
- **Onboard Equipment (OBU)** — Devices located in the vehicle either as standard equipment or as an after-market device. OBU's process, store, and provide communications functions necessary to support connected vehicle operations. Using Dedicated Short Range Communications (DSRC) or other alternative wireless technologies, OBU's interface with the standard equipment or aftermarket safety devices to communicate information to the driver.
- **Nomadic Device** — Whether it be a pedestrian, bicyclist, or wheelchair user the nomadic device is located on the traveler and provides information to the vehicle drivers.
- **Traffic Signal Controller** — Allows the traffic signal to communicate between motorized and non-motorized users utilizing data streams to maximize safety and traffic flow through the intersection.
- **Backhaul Communications** — A secure communications network between the highway agency and roadside unit to disseminate accurate and useful information to the driver.
- **Vehicle to Vehicle (V2V) Communications** — The wireless exchange of data among vehicles in close proximity.
- **Vehicle to Infrastructure (V2I) Communications** — Wireless exchange of critical safety and operational data between vehicles and the roads they use.
- **Dedicated Short Range Communications (DSRC)** - A technology similar to Wi-Fi which is fast, secure and reliable that can be used continuously share important safety and mobility information between road users and the roadway infrastructure.
- **Light Detection and Ranging (LiDAR)** – High resolution radar that provides a detailed real-time digital map of the surrounding area. Typically used on vehicles to provide precise situational awareness for on board systems to react to.
- **Back-office data processing** – the ability to collect and process data over V2I systems is critical to creating value of the system both to MDOT and to end-users. MDOT has developed this capability building on the Data Use Analysis and Processing (DUAP) system, a data aggregation tool developed by the department to enable greater use of a large range of internal and external data sources for better management of the overall transportation system.

CAV Advancement in Michigan

History of CAV Research in Michigan



In addition to the tremendous private sector activity undertaken in the state, Michigan has been the site of some of the most significant state and federally-supported research and testing initiatives ever conducted – initiatives which serve as the foundation of today's federal connected vehicle program.

Starting in 2005, the United States Department of Transportation (USDOT) conducted the national CV Proof of Concept (POC) testing in suburban Detroit. The test served as a basis to validate the functionality of DSRC, pilot use cases and applications, and the architecture of the system. The Southeast Michigan Connected Vehicle Test Bed used for the POC testing was retained and updated over time by USDOT as a key regional resource to support further testing and development, including implementation of the USDOT's Connected Vehicle Reference Implementation Architecture (CVRIA).

In 2007 MDOT created their first business plan, the Vehicle-Infrastructure Integration Strategic and Business Plan, targeting transportation technology

innovation which set a course of action toward developing the required public and private sector partnerships that would ensure leadership, innovation, and progress across the state. The strategy identified partnering, developing and deploying technology infrastructure and testbeds targeting increases in safety and mobility; improving asset management; developing outreach programs to better expose others to the technology within the state and to help justify the need for it as well as help define funding opportunities.

The following year, in 2008, MDOT developed a specific updated transportation technology business plan, the Line of Business Strategy for Vehicle-Infrastructure Integration, which initiated a course of action toward establishing the needed public and private sector partnerships that would ensure leadership, innovation and progress. The strategy again focused on partnering, developing and deploying transportation technology infrastructure and technology testbeds and further defining the

justification and funding through a set of specifically identified goals and activities.

In 2011, a team led by the University of Michigan Transportation Research Institute, with support from both MDOT and the Michigan Economic Development Corporation (MEDC), was selected to conduct the Safety Pilot Model Deployment, and multi-year effort to create the largest scaled deployment of CV technologies in the world, including nearly 3,000 equipped vehicles and 30 CV roadside installations. The data collection and analysis

conducted as part of the Safety Pilot program served to justify the value of V2V technology, and ultimately triggered the start of a rulemaking process to mandate such technology in light vehicles in the U.S.

In addition to strong Federal investment, MDOT has similarly invested in strategic projects to further CAV technologies. One such major project, the Data Use Analysis and Processing (DUAP) project, serves as a data collection, aggregation and processing platform, a critical piece of the connected vehicle ecosystem.

Michigan's Place on the Global Stage

Michigan is positioned as a key global leader in connected and automated vehicle research and technology.

Michigan is a global leader in research and development activities that have allowed for a significant number of local CAV projects to be undertaken. As vehicle and transportation technologies continue to evolve, Michigan will continue to lead the way. The entire state, with the auto industry and technology partners, are transforming into the global center for mobility. Home to unrivaled automotive R & D and advanced manufacturing assets, Michigan is positioned as the global center of CAV technology. The research, design, testing and infrastructure development that is revolutionizing mobility, connecting the automobile and reshaping the world of mobility is happening within Michigan.

MICHIGAN...

- ✱ **is the home to the largest deployment of V2I technology in the United States, with plans for 350+ infrastructure miles wired for V2I.**
- ✱ **leads the nation in patents relating to navigation and smart mobility.**
- ✱ **in 2016 led the nation in connected vehicle projects – 45 in total – which represents a growth of 50 percent over the previous year.**
- ✱ **is home to an all-weather environment, which is critical in testing automated technologies.**
- ✱ **ranks first in the nation for its concentration of engineering talent: Is home to 89,000 engineers and is ranked No.1 nationally for the number of advanced automotive industry jobs (67,825) and businesses (462).**
- ✱ **offers the second largest system of adaptive traffic signals in the United States.**
- ✱ **has its freeways well instrumented with 450 closed circuit TV cameras, 200 dynamic messaging signs and 500 microwave vehicle detector sites.**

Michigan has become the strategic location for emerging technology in connected and automated vehicles. It boasts a large deployment of video imaging for traffic management and the most extensive system of CAV related test beds worldwide. Auto manufacturers and suppliers are present here with seven local global or North American research and development (R&D) headquarters and eight original equipment manufacturers (OEMs) research

and development facilities. Michigan schools have specialized programs to focus on automotive technology and design, such as the K-12 Square One program, as well as related community college and university programs. And by late 2017, Michigan will be home to two permanent and purpose-built automated vehicle testing sites, Mcity, and the American Center for Mobility; nowhere else in the U.S. has resources like these facilities.

Michigan is the National Center for Automotive Research

Michigan strives to maintain the state's position as the global center for automotive advancement and to showcase strategic opportunities in smart technology and next generation mobility. Current CAV efforts are working to leverage Michigan's assets and grow opportunities in smart mobility.

In partnership with private industry, academia and government agencies Michigan is utilizing its talent and resources to further research on how CAV systems operate: Improving safety and mobility with applications that operate in concert with crash avoidance technologies that are currently or soon to be available to consumers in their vehicles.

The University Research Corridor, an alliance between the University of Michigan, Michigan State University and Wayne State University, plays a direct role in automotive innovation by spending over \$60 million annually on auto-related R&D. And eight major automotive manufacturers are providing support for this research through partnering agreements:

- Ford Motor Company
- General Motors LLC.
- Honda R&D Americas, Inc.
- Hyundai-Kia America Technical Center, Inc.
- Mercedes-Benz Research and Development North America, Inc.
- Nissan Technical Center North America

- Toyota Motor Engineering & Manufacturing North America, Inc.
- Volkswagen Group of America, Inc.

Michigan is home to 375 research and innovation and testing centers across the state which work in transportation, a few include the:

- American Center for Mobility at Willow Run
- Center for Advanced Automotive Technology (CAAT) - Macomb Community College
- Coleman A. Young International Airport
- CAV Trade Association (CVTA)
- Michigan Mobile Technology Association (MMTA)
- Detroit Innovation District
- Detroit Test Bed
- FCA US LLC Headquarters and Technology Center
- Joint Ground Robotics Enterprise - TACOM
- Automated and Interconnected Vehicles Lab - Lawrence Tech University
- Mcity
- Michigan International Speedway Vehicle Testing Facility

- Michigan Tech Research Institute and the Transportation Institute
- PrePass, Monroe, MI
- NextEnergy, Detroit
- Oakland County Connected Car Task Force
- Roush Building (Google Driverless Cars)
- The Smart Corridor
- Southeast Michigan CAV Test Bed
- Southeast Michigan Transportation Operations Center (SEMTOC)
- U.S. Army Tank Automotive Research (TARDEC)

Key Legislative Support

Since 2013, the Michigan Legislature has been an active partner in supporting the development of connected automated technology testing.

Senate Bill 169, signed into law by Gov. Rick Snyder in December 2013, allows for the testing of driverless cars on Michigan roads. The law comes with certain stipulations, such as a licensed driver must be behind the wheel at all times and be ready to take over control.

Additional legislation to update Michigan's law was introduced with strong bi-partisan support in 2016. Five key provisions are at the forefront of this legislation:

1. Allows open operation of CAVs beyond testing by repealing the test only restriction. The goal is recognizing testing of automated vehicles is quickly advancing through controlled environments, and we are entering the stage where more routine test on public streets and highways will be desired.
2. Allows on-demand automated vehicle networks to link passengers and various forms of transportation with automated vehicles. Customers will be able to request a ride via a network operator which will direct a vehicle to the customer location and then onto a desired destination. The goal is to eventually provide this ride via automation or without a human operator in the vehicle.

3. Allows vehicle platoons where vehicles can travel together with electronically coordinated speeds. The goal is to allow fleets of vehicle to move in coordinated trips taking advantage of efficiencies in fuel consumption and operations.
4. Established the American Center for Mobility at the former Willow Run plant into state law. The goal is to provide a world class research facility that will build on the intense activity already seen at MCity, and provide real world conditions in weather, road conditions and traffic situations for researchers.
5. Penalizes persons who hack or damage automated vehicles to impair the technology or gain unauthorized control of the vehicle. The goal is to penalize those who would abuse automated technology for mischief or more serious public safety situations.

In addition, there are related amendments including the creation of the Council on Future Mobility to continually update policy makers on future changes needed to remove statutory and regulatory barriers.

As a result of this legislative work CAV research has had significant legal barriers lowered or removed in Michigan allowing the use of automated vehicles to be dependent on the development of technology rather than statutory limits.

Infrastructure and Vehicle Assets

Existing ITS Devices and Communications Systems

MDOT has deployed robust network of ITS devices throughout Southeastern Michigan freeways. The Metro region (Wayne, Oakland and Macomb Counties) alone boasts nearly 700 devices, including 313 cameras, 96 Dynamic Message Signs (DMS), 286 detectors, and over 200 miles of fiber complete or under construction. In addition, 7 curve warning systems now deployed, and a new bridge deck warning system is under development.

Additionally, MDOT has developed a deployment plan for ITS on arterial roadways, including

communications, signal system interconnection, and supporting devices. As an example, these systems were constructed on a portion of M-1 (Woodward Avenue) coinciding with the QLine streetcar project. Construction is anticipated in 2018 on other significant corridors in the region, including M-59 (Hall Road).

Operations and Incident Management Systems

MDOT's ITS program focuses on executing incident management activities; providing construction activity information; reducing congestion and crashes along the interstates and arterial corridors;



and providing real time traveler information to the public. MDOT operates several Transportation Management Centers (TMC's), and manages a robust fleet of Freeway Courtesy Patrols that service disabled vehicles, assist motorists in need, and provide additional eyes and ears along Metro Region roadways.

MDOT partners with local agencies and emergency responders to assist with stakeholder coordination, DMS messaging, and traffic monitoring. The TMC's serve as a communication HUB used to capture, store, and disseminate essential transportation related information. And MDOT utilizes the MiDrive website (www.michigan.gov/drive) to provide travelers with an interactive map that presents traffic camera images, average vehicle speed, environmental sensor information, and construction activity.

Fleet Vehicles

The Michigan DOT Fleet current has 15 vehicles instrumented with the MDOT Vehicle Based Information and Data Acquisition System (VIDAS). The platform consists of a Data Acquisition System with the ability to communicate asset condition (sensor) data with high accuracy GPS via multiple communication paths (i.e., cellular, Wi-Fi, and Dedicated Short Range Communications (DSRC)).

The VIDAS platform collects the following data elements: GPS (location, speed, heading), weather sensors (air temperature, barometric pressure, pavement surface condition), Controller Area Network (CAN) Bus (vehicle diagnostic data), 3 Axis Accelerometry (X, Y, & Z deflection), and Acoustic Distance Measurement (Distance from vehicle suspension to road surface).

The purpose for gathering the data is to support current and future application development under the MDOT Data Use Analysis and Processing (DUAP) Research Project. Applications to be supported by this data collection system includes but is not limited

Connected Vehicle Infrastructure

Southeast Michigan is home to some of the world's largest CV pilot deployments. Beginning in the mid-2000's with Proof of Concept testing conducted by the U.S. Department of Transportation (USDOT), large pilot deployments have been conducted in the region, including the Safety Pilot Model Deployment in Ann Arbor, Michigan, and deployment conducted for the 2014 ITS World Congress held in Detroit. While formal pilot activities are continuing at these various deployment sites, these assets have been viewed by regional partners and the USDOT as a strong foundation for a sustainable regional deployment.

Michigan boasts over 115 DSRC Roadside Units (RSU) for connected vehicle communications throughout the state. Most of these units are concentrated in four test site clusters around Southeast Michigan, with deployments planned in 2017 in several locations (see Appendix A).



to; Mobility, Pavement (Defect Detection, Surface Roughness) and Weather (Hazardous Condition Detection (Icy Pavement), Weather Responsive Traveler Info).

The VIDAS platform, coupled with the DUAP applications, will provide MDOT with the ability to better manage roadway assets, and improve operations and maintenance by providing more real-time data collection by utilizing a mobile collection (Connected Vehicle) platform.

CAV Program Goals and Strategies

This previous work has helped position MDOT's efforts to support and advance CAV technologies. Each of these documents defined a vision and a mission for MDOT to help support their efforts. Building on these previous efforts and as a way to provide some consistent guidance moving forward MDOT's CAV vision and mission statements have been updated to reflect the success of efforts to date and to recognize the rapidly changing environment of CAV technologies moving forward.

Program Vision

The Michigan Department of Transportation will be recognized as a progressive and innovative leader, driving national efforts to explore and implement emerging mobility technologies.

Program Mission

The Michigan Department of Transportation will work to ensure Michigan remains the national leader in the evolution of CAV technologies, to deliver enhanced transportation safety and reliability, providing economic benefit and improved quality of life.

Table 1 illustrates the relationship between these vision/mission statements, and those of the department-wide and Transportation System Management & Operations (TSM&O) vision and mission statements.

Table 1: Mission and Vision Statement Alignment

	Mission Statement	Vision Statement
MDOT (Department-Wide)	Providing the highest quality integrated transportation services for economic benefit and improved quality of life.	MDOT will be recognized as a progressive and innovative agency, with an exceptional workforce that inspires public confidence.
MDOT TSM&O Program	Operate and manage an optimized, integrated transportation network by delivering high quality services for safe and reliable mobility for all users	<ul style="list-style-type: none"> ■ Integrate Operations as a core MDOT program united with the execution of MDOT's overall mission ■ Inspire public confidence as a progressive and innovative national leader in the management and operations of our transportation system ■ Collaborate across program areas, leveraging technology and resources to achieve the best possible results ■ Maintain a sustainable and engaged operations workforce with exceptional knowledge, skills, and abilities
MDOT CAV Program	MDOT will work to ensure Michigan remains the national leader in the evolution of CAV technologies, to deliver enhanced transportation safety and reliability, providing economic benefit and improved quality of life.	MDOT's CAV Program will be recognized as a progressive and innovative leader, driving national efforts to explore and implement emerging mobility technologies.

Program Goals

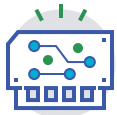
With this vision and this mission in mind and with the rapid pace of development of CAV technologies MDOT needs a well-informed and well-defined approach to be prepared and engaged in CAV technology. This approach will recognize that MDOT's CAV programs' mission, vision, and actions are built upon and support the overriding guiding principles and objectives of the agency as a whole.

To support MDOT's CAV vision and this mission the following program goals have been identified.



Goal 1: Serve as a national model to catalyze CAV deployment

The USDOT and peer agencies will look to Michigan for a roadmap for how to plan, design, build and sustain CAV deployments, including identification of innovative business models for CAV.



Goal 2: Establish foundational systems to support wide-scale CAV deployment

MDOT will develop foundational systems and standards, such as data management, backhaul communications, and IT/security standards to enable sustained deployment activity.



Goal 3: Make Michigan the go-to state for CAV research and development

Michigan will have the combination of assets, human capital and experience necessary to keep current CAV research and development activities in the state, and draw new activities here to create economic benefit for the state.



Goal 4: Accelerate CAV benefits to users

MDOT will identify ways to add value for our customers today and in the near future during the transitional timeframe of connected and automated vehicles on our roadways.



Goal 5: Exploit mutual benefit opportunities between CAV technologies and other department business processes and objectives

MDOT will explore ways to leverage CAV data, safety and operational benefits to support and enhance other business processes.



Goal 6: Use Michigan experience to lead dialogue on national standards and best practices

MDOT will engage in industry groups, peer agency alliances, and with the private sector to share experiences, support peer agency activities, and guide V2I standards development.

CAV Program Strategies

Table 2 presents the strategic actions identified in order to achieve the established goals for the CAV program. These actions reflect a range of on-going activities and future priorities for MDOT to fulfill the program mission and achieve the vision.

Table 2: MDOT CAV Program Strategies

Strategy	Description
1.0 Foundational Actions to Institutionalize CAV	
1.1 Institutionalize CAV in related MDOT initiatives	Going forward, CAV will be integral to a wide range of MDOT programs and initiatives, including Transportation Systems Management and Operations (TSM&O), Towards Zero Deaths (TZD), MDOT's initiatives to identify and fulfill Wildly Important Goals (WIG), and the top-level business and strategic planning for the broader ITS program. Through inter-departmental outreach, education, and business planning, MDOT will work to promote the consideration and integration of CAV into related initiatives throughout the department.
1.2 Institutionalize IT and security for CAV	The introduction of CV radio technology on the state network for V2I communications presents a unique challenge in terms of networking and security. To address this challenge, MDOT will partner with the Department of Technology, Management, and Budget (DTMB) and the private telecommunications industry to develop best practices and standards to secure the system, address installations, and create the required outside connections to reach security certificate and data management systems off the State network.
2.0 CV Infrastructure Deployment	
2.1 Develop CV-related design and deployment standards	While significant CV infrastructure has been deployed throughout Michigan, the standards and processes for that deployment are still largely under development. In order to prepare for future sustainable deployment, MDOT will standardize the deployment process, including establishing approved design standards and specifications for CV-related equipment, addressing requirements to support CV as part of traffic signal controller standards, and defining the roles of various parties in the design, construction and integration processes.

Strategy	Description
2.2 Develop plan for large-scale V2I deployment	In order to plan for on-going infrastructure deployment, MDOT will develop and keep up to date a roadmap for deployment is needed which identifies locations with characteristics which could benefit from deployment of targeted V2I applications (see Action 3.1). This could include geometric constraints, crash history impacted by weather conditions, anticipated work zone locations, and others.
2.3 Lay foundation for CV in other infrastructure projects	CV systems will greatly increase needs for communications infrastructure throughout the MDOT roadway network. This includes both conduit for fiber optic/wired communications, as well as physical cabinet space at ITS and traffic signal installations to house additional equipment. MDOT will build provision of this infrastructure into all projects today to support CV deployment tomorrow, including identifying decision criteria for project managers to determine appropriate provisions specific to the nature of their project.
2.4 Developing foundational data management systems	CAV systems have the potential to provide MDOT with a tremendous amount of data which could be used to support agency business processes. In addition, there is a need for centralized generation of infrastructure-based messaging (for instance, for dynamic applications such as spot weather warning) to support some V2I applications. MDOT will continue investment in data management systems, including evaluating continued investment in existing tools such as the Data Use, Analysis and Processing (DUAP) program or new systems, to allow for management of this data flow, conversion of the data to actionable information, and ability to generate infrastructure-based dynamic messages are essential to creating value to the department.
2.5 Deploy CV infrastructure to support other strategic initiatives	In cases where fulfillment of other strategies included in this plan would benefit from public CV infrastructure, MDOT will look to deploy such infrastructure in coordination with potential partners, and with consideration of alignment with transportation issues and needs in those deployment locations.
2.6 Identify and deploy infrastructure improvements to support automated vehicle deployment	Infrastructure needs, such as enhanced pavement markings, signage, and digital mapping resources, are still emerging. MDOT will monitor trends and dialogue with AV developers to understand these needs, and adjust program priorities across the department to best meet these needs.

Strategy	Description
3.0 Application Development and Benefit Acceleration	
3.1 Support development of high-priority V2I applications	V2I applications have both tremendous potential to improve safety and mobility, and a clear public agency role in supporting and deploying. Further, in the early years of deployment, V2I has been identified as critical to creating value for equipped vehicles before fleet penetration rates are sufficient for significant V2V interactions. MDOT has identified the following as high-priority V2I applications which the department will support development of: Work zone, pavement condition, road weather, and SPaT-enabled applications. Further, MDOT will continuously evaluate new focus applications which target the department's safety and reliability objectives.
3.2 Accelerate CV benefits through use of mobile technology	While proliferation of equipped vehicles is dependent on a number of factors not controlled by MDOT, benefits of CV technologies can be accelerated through the use of mobile technology. MDOT will seek to develop partnerships and provide agency data to those partners to support beneficial "V2I" mobile applications to transportation system users.
3.3 Accelerate CAV benefits through fleet deployments	Equipping MDOT and partner fleet vehicles is one method of accelerating CV benefits, both to the drivers of those vehicles, and to the department through the acquisition of data. MDOT will seek to outfit vehicles to support benefit acceleration and regional testing activities.
4.0 Michigan Industry and Workforce Development	
4.1 Support industry research, testing and education in Michigan	Industry development is critical to both MDOT's core mission, and Michigan's economic future. As such, MDOT will leverage its assets and human resources to support industry partners in conducting research and testing in the state, including academic institutions, research consortiums, and individual companies.
4.2 Play leadership role in developing Michigan's CAV workforce	To further the state's economic objectives, MDOT will support and promote initiatives to develop a workforce in the state capable of meeting future industry needs, including assisting with curriculum development, direct training, and supporting third-party workforce initiatives.

Strategy	Description
5.0 Partnering and Promotion	
5.1 Create mechanism for fostering, evaluating and selecting future industry partnerships	Through MDOT's leadership to date in CAV technology development, numerous partners have expressed interest in working with the department on a range of initiatives. To support the ability to select appropriate partners best positioned to help MDOT achieve the CAV program goals, the department will develop criteria to evaluate prospective partners, as well as identify key partnership gaps.
5.2 Support strategic partnering to advance state and/or regional positioning	MDOT will seek and actively support alliances with the USDOT, peer DOT's, other transportation agencies, industry groups and/or academic partners both inside and outside of Michigan when necessary/advantageous to help achieve MDOT program goals.
5.3 Partner with other state agencies to support CAV goals	MDOT will seek partnership with other state agencies, such as Michigan State Police (MSP), the Michigan Economic Development Corporation (MEDC), the Department of Technology, Management and Budget (DTMB) and others, to help achieve MDOT program goals and to exploit mutual benefit opportunities.
5.4 Promote Michigan CAV activities through industry and public forums	MDOT will take an active role in "telling the story" about CAV and advanced mobility initiatives happening in Michigan, through participation in industry activities and forums, and through related public events.
5.5 Play a leadership role in establishing national direction and best practices	MDOT will advance the state of the practice and development of standards by actively engaging and sharing experience and lessons learned with leading industry groups and standards bodies.

Table 3 illustrates the alignment between these strategies and the program goals, to show the relationship between the two and how goals are anticipated to be achieved.

Table 3: Alignment between Goals and Strategies

	Serve as a national model to catalyze CAV deployment	Establish foundational systems to support wide-scale CAV deployment	Make Michigan the go-to state for CAV research and deployment	Accelerate CAV Benefits to users	Exploit mutual benefit opportunities between CAV technologies and other department business processes and objectives	Use Michigan experience to lead dialogue on national standards and best practices
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5	Goal 6
1.1 Institutionalize CAV in related MDOT initiatives			X			X
1.2 Institutionalize IT and security for CAV	X	X		X		X
2.1 Develop CV-related design and deployment standards	X	X				
2.2 Develop plan for large-scale V2I deployment	X		X	X	X	X
2.3 Lay foundation for CV in other infrastructure projects	X	X		X	X	
2.4 Develop foundational data management systems	X	X	X	X	X	X
2.5 Deploy CV infrastructure to support other strategic initiatives	X	X	X	X	X	
2.6 Identify and deploy infrastructure improvements to support automated vehicle deployment	X		X	X		X
3.1 Support development of high-priority V2I applications	X		X	X		X
3.2 Accelerate CV benefits through use of mobile technology	X		X	X		X
3.3 Accelerate CAV benefits through fleet deployments	X			X	X	X
4.1 Support industry research and testing in Michigan			X	X		
4.2 Play leadership role in developing Michigan's CAV workforce	X		X			X
5.1 Create mechanism for fostering, evaluating and selecting future industry partnerships			X	X	X	
5.2 Support strategic partnering with peer organizations to advance state and/or regional positioning			X			X
5.3 Partner with other state agencies to support CAV goals	X	X		X	X	X
5.4 Promote Michigan CAV activities through industry and public forums	X		X			X
5.5 Play a leadership role in establishing national direction and best practices	X	X	X	X		X

Current Projects/Tactical Actions

MDOT is currently undertaking a wide range of projects and initiatives aimed at meeting department goals for the CAV program. The following is a summary of these initiatives, including location, status and level of investment.

I-94 Road Weather Program

Location: Washtenaw/Wayne County line easterly to Blue Water Bridge

Status: Design/Partnering (Construction in late 2017)

MDOT plans to deploy DSRC communications along I-94 through a significant portion Southeast Michigan to support weather-related V2I applications. This section of freeway exhibits a high crash rate due weather related incidents due to unique terrain and surroundings. This deployment will provide an opportunity to integrate CV and weather-related systems to test applications which could warn motorists of micro-level weather conditions in an effort to reduce associated crashes.

M-53 SPaT/Transit Signal Priority Deployment

Location: Various locations in Macomb County

Status: Design

MDOT is partnering with the Suburban Mobility Authority for Regional Transportation (SMART), the suburban transit system for the Detroit region, and Macomb County to provide transit signal priority using CV-technologies to SMART buses along key routes within the county. The deployment will leverage roadside and onboard DSRC units as a mechanism to communicate priority calls to the signal controller in order to provide improved travel time reliability and reduce travel delays.

I-275 Curve Speed Warning Deployment

Location: I-96/M-14 to I-75

Status: Design

MDOT is collaborating with multiple industry partners on supporting testing of curve speed warning V2I applications. A deployment of DSRC RSUs is under design along the I-275 corridor at key mainline and ramp curve locations, which will enable broadcast of curve geometric and advisory speed data to support in-vehicle warning applications.

M-43 (Saginaw Highway) CV Deployment

Location: M-43 near I-96, Ingham County

Status: Operational

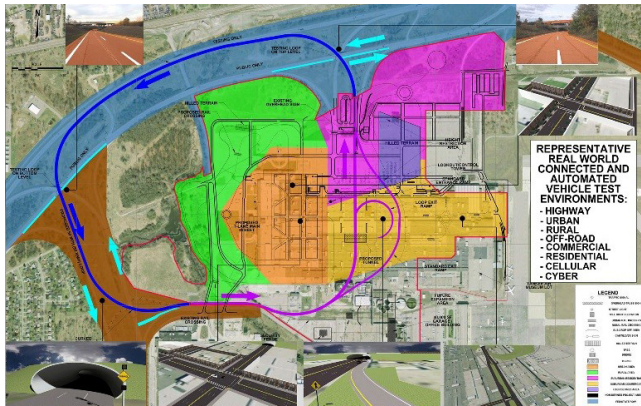
The Saginaw Highway corridor has nine signalized intersections that received a complete signal system upgrade in late 2012. These controllers are fully capable of transmitting the signal phase and timing (SPaT) plans at 0.1 second intervals in National Transportation Communications for ITS Protocol (NTCIP). In 2016, MDOT deployed connected vehicle infrastructure at these nine intersections along the Saginaw corridor, enabling the broadcast of Signal Phase and Timing (SPaT) data to connected vehicles in the area in order to best SPaT-based safety and mobility applications.

US-12 Test Bed Deployment

Location: Ypsilanti Township

Status: Construction

In support of the American Center for Mobility (ACM) at Willow Run, a nationally-designated automated vehicle (AV) proving ground set to open in late 2017, MDOT is deploying DSRC RSUs along the US-12 corridor. This corridor, adjacent to the ACM site, connects I-94 and I-275, in what will become a connected loop surrounding this AV test site, allowing for test vehicles to proceed off the test site and into a connected open-road environment to further testing and certification efforts. The deployment is occurring in conjunction with the conversion of one direction of US-12 to bi-directional traffic, making way for re-use of under-utilized roadway capacity as part of the test facility. The deployment is expected to be operational in late 2017, coinciding with the opening of the ACM facility.



Mound Road Signal Phase and Timing (SPaT) Deployment

Location: Warren

Status: Operational

In support of testing activities nearby the General Motors Technical Center in suburban Detroit, MDOT in partnership with the Macomb County Department of Roads (MCDR), deployed connected vehicle infrastructure at two intersections along the Mound Road corridor, as well as a portable unit inside the Tech Center campus, enabling the broadcast of Signal Phase and Timing (SPaT) data to connected vehicles

in the area in order to best SPaT-based safety and mobility applications. The deployment required significant collaboration to generate messages adhering to the most recent standards established by the Society of Automotive Engineers (SAE), and coordination of communications through the MCDR signal system, and to the DUAP system servers in order to capture data over the network.



Auburn Hills Test Bed Deployment

Location: Auburn Hills

Status: Construction/Deployment

In partnership with the Road Commission for Oakland County (RCOC), MDOT is working with Fiat Chrysler Automobiles (FCA) on deploying RSUs at several intersections around the FCA campus in Auburn Hills to support the testing needs of FCA and their supplier partners. The three initial RSUs (with ten additional planned for a future deployment phase) will support SPaT broadcast, and data capture for FCA testing and analytics. The deployment includes the addition of D4 signal controllers, which were successfully deployed for SPaT functionality in Macomb County.

I-75 Test Bed Deployment

Location: Oakland County

Status: Construction/Deployment

As part of the I-75 Modernization Program, a \$1B+ 20-year freeway improvement project, MDOT is deploying RSUs to support both construction activities and long-term operational needs in the corridor.

Temporary RSUs being provisioned will broadcast work zone messages to support testing of work zone information and safety applications. Each construction segment includes provisioning of permanent RSUs co-located at all ITS sites along the corridor.

Collision Avoidance and Mitigation System (CAMS)

Location: Southeast Michigan

Status: Operational Study through 2018

CAMS is a partnership between MDOT and industry partners to improve safety and mobility. Each winter, Winter Maintenance Trucks (WMTs) through the state have collisions with other vehicles in close proximity (behind/alongside) while traveling along state roadways. The purpose of this research study is to measure the data collection effectiveness/impact/benefit using sensor technologies and in-cab alert systems with rear-facing views, as a tool to prevent, reduce and mitigate collisions of maintenance and passenger vehicles. These existing technologies, if implemented by MDOT, have the potential to save lives, and to reduce medical and vehicle repair expenses, and user delay costs.

Weather-Responsive Traveler Information System (Wx-TINFO) Program

Location: Statewide

Status: Operational, under further development



MDOT is responsible for the successful deployment and operation of a statewide Road Weather Information System (RWIS). Other MDOT initiatives

such as Integrated Mobile Observations (IMO), Advanced Applications of Connected Vehicle Data Use Analysis and Processing (DUAP), and Vehicle-based Information and Data Acquisition System (VIDAS), are capable of producing, collecting, and/or processing environmental/weather data. With support from the Federal Highway Administration (FHWA) on the Wx-TINFO project, MDOT and its project team deployed a system to bring together this near-time environmental/weather data from the mobile and fixed data sources from these initiatives.

Wx-TINFO operates as a statewide implementation, and utilizes the state's traveler information systems such as the Advanced Traffic Management System (ATMS) software, roadside Dynamic Message Signs (DMS), and the MiDrive website to provide the traveling public with meaningful warnings, alerts, and advisory messages so they can make more informed decisions before and while traveling Michigan's roadways during inclement weather. Further development is focusing on using connected vehicle to both collect weather observations and to receive weather warning messages via various CV communications media.

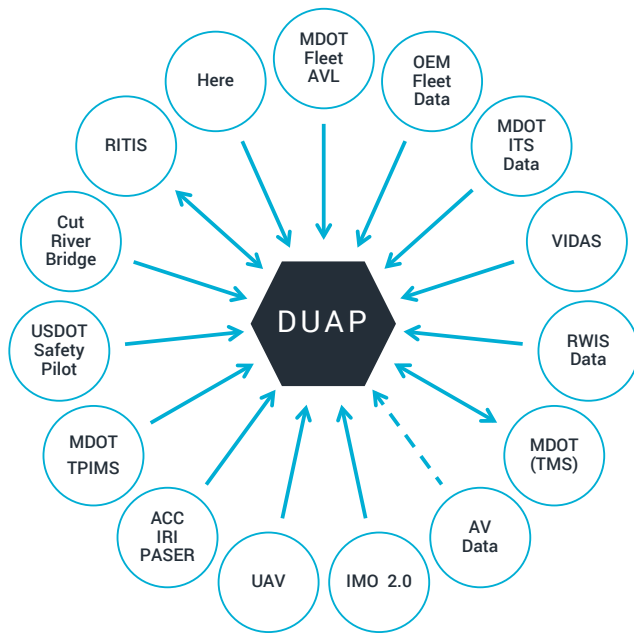
Data Use, Analysis and Processing (DUAP) Program

Location: Statewide

Status: Operational, on-going expansion

The MDOT DUAP program provides a platform and system that supports performance management by enhancing agency-wide usage of CV data, mobile data, and fixed data to increase data sharing, availability, and awareness across the agency. By accomplishing this objective, MDOT decision makers will be equipped with more robust, near-time data from CVs, mobile platforms, and other internal MDOT systems. Receiving this information on a timelier basis will allow for decision making in support of agency objectives at reduced costs and with increased operational efficiency. Towards this objective, the cornerstone of the DUAP program is to integrate CV data, mobile data, and fixed data into a unified system of systems that is accessible by personnel

across MDOT. This will provide MDOT system users with a platform to iteratively define, analyze, and refine their need for making decisions.



The DUAP system itself is a large-scale data collection system designed to ingest data from multiple data sources to be processed, stored and made accessible to users of the system. It is also designed to be flexible, scalable, and maintainable, while providing the following capabilities:

- Operate as a collection point for large amounts of data from many sources
- Allow new data sources to be integrated as they become available
- Sustain existing data sources that are still viable
- Minimize costs by creating processes that are configurable
- Act as a collection of processing methods for:
 - Parsing data from its original format
 - Transforming data into more useful formats
 - Storing data in a database
 - Securing data
 - Ensuring data integrity
- Provide the means for accessing data from the database

- Provide a collection of web services that process the stored data to provide information
- Provide a collection of developed applications that share and disseminate information to the users of the system
- Act as a data source for other MDOT systems and applications

I-69 Truck Platooning Test Support

Location: St. Clair County

Status: Complete

The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) located in Warren, Michigan, is the Army's leading developer of ground vehicle technology. Collaborating with MDOT is a natural fit, as Michigan's roadways provide TARDEC with the ability to test new capabilities nearby in a spectrum of real-world environments.



TARDEC has also found in MDOT a collaborative partner who leans forward with us, looking to stay ahead of the rapid advances in automobile and mobility technology. Where MDOT can provide the environment and support for honing these technologies on the public roadways, TARDEC provides the technological expertise and background in testing and evaluation techniques.

TARDEC and MDOT are coordinating to conduct testing of dedicated short-range radio (DSRC) systems between roadside radios and TARDEC convoy vehicles. These tests pave the way for future TARDEC tests of its advanced platooning and automated

driving technologies, whose use on public roadways will require effective and efficient digital communication with civilian vehicles and infrastructure. Collaborative partnership—like that which TARDEC shares with MDOT—streamline the innovation and capability development process for the Warfighter while enhancing the automobile research and development focus in Michigan.

USDOT Test Bed Infrastructure Transition

Location: Novi/Farmington Hills

Status: Operational, transition in discussions

The United States Department of Transportation (USDOT), through early research programs such as the Proof of Concept (POC) testing conducted in the late 2000's, developed a test bed infrastructure, including both roadside infrastructure and back-end systems and tool kits, in Oakland County, Michigan. This infrastructure has continued to serve researchers and automotive industry test needs, as well as serving as a live test site to incubate CV tools, such as the situation data clearing house and other prototype systems meant to serve as models for broader national deployment.

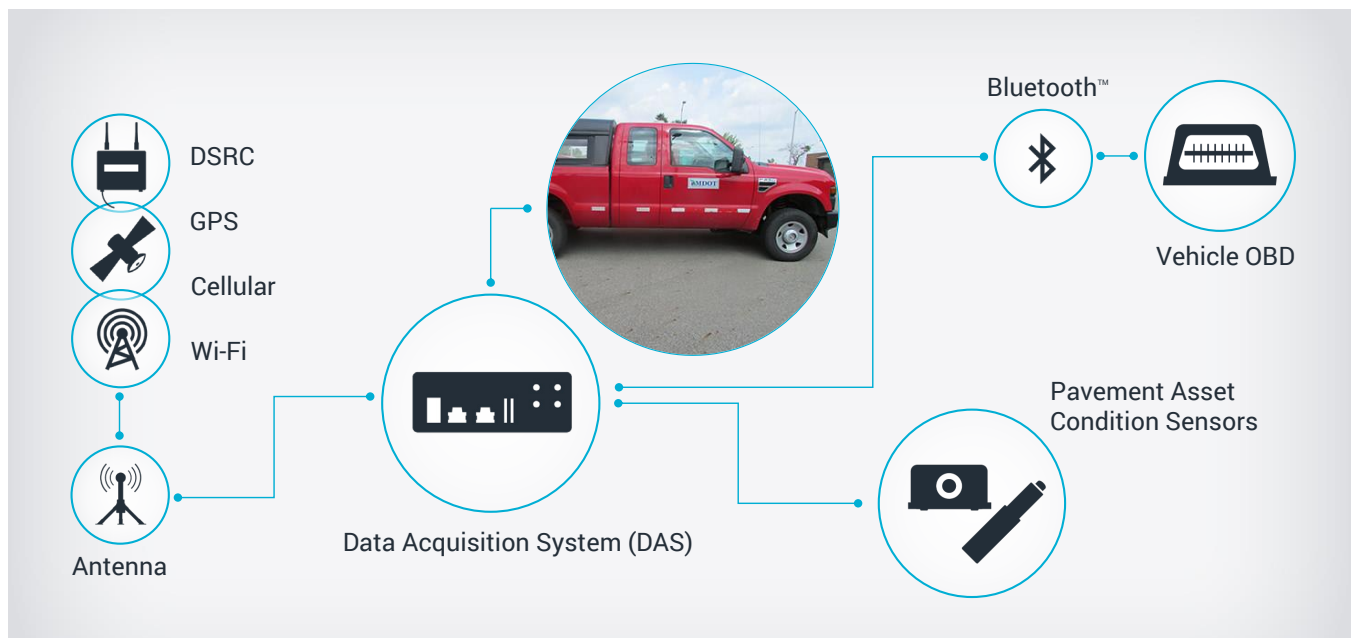
MDOT is in discussions with USDOT, along with the Road Commission for Oakland County (RCOC), to transition the USDOT's Southeast Michigan test bed assets to MDOT for long-term operation and further development. This includes nearly 50 RSUs deployed at intersections throughout the suburban communities of Novi and Farmington Hills. The infrastructure would be transitioned onto the common communications and management systems being used by MDOT for deployments throughout the state.

Vehicle-Based Info Data Acquisition System (VIDAS) Program

Location: Statewide

Status: Operational

The use of probe data for gathering pavement condition information has great potential for improving real-time maintenance decision-making and long term rehabilitation project planning processes, while ultimately reducing costs. It is possible for accelerometer data from vehicles to ultimately replace traditional manual collection methods for pavement condition. However, even on today's connected vehicles, this data package is not yet available in the message standards.



VIDAS System Architecture

To address this issue, MDOT has developed the Vehicle-Based Info Data Acquisition System (VIDAS) as a mechanism to turn public fleet vehicles into data probes. The VIDAS system is able to collect a host of probe data from the vehicle, including telemetry and environmental data, and transmit it via cellular, DSRC and Wi-Fi communications to MDOT's DUAP system servers. DUAP includes applications that are then able to process this data into usable information for decision support with regards to maintenance activities and long-term pavement management. By fusing together traffic volume data, weather information, and vehicle accelerometer data, DUAP is capable of detecting more than 30 types of pavement defects, including buckling, linear cracking, spalling and many others. This system has been successfully deployed and is operational in a number of MDOT fleet vehicles today.

McCity

Location: Ann Arbor

Status: Operational

MDOT is a partner in McCity, the University of Michigan's advanced mobility test site and incubator,

contributing both funding and expertise to the launch of the McCity CAV test facility. In its partner capacity, MDOT advised the design of the McCity facility, supported affiliated CV deployment on surrounding freeways, and is a continued partner in deployment extension and data collection efforts. McCity is a C/AV research facility focused on testing of prototype-level technologies both on-street and in a closed track environment.

American Center for Mobility

Location: Ypsilanti Township

Status: Construction

The American Center for Mobility, a 330-acre CAV test facility on the site of the historic Willow Run bomber plant, is a joint initiative between MDOT, the Michigan Economic Development Corp. (MEDC), Business Leaders for Michigan, Ann Arbor SPARK, and the University of Michigan. MDOT has provided staff resources and expertise to launch this innovative testing facility, one of ten nationally-designated AV Proving Grounds by USDOT. ACM is intended as a testing and certification facility for commercial C/AV systems.

Programmatic Support Activities

Southeast Michigan V2I Deployment Plan

As part of the strategic planning process for CAV, MDOT has undertaken the development of a deployment plan for V2I systems for Southeast Michigan, targeting deployment locations where conditions (including geometric configuration, volumes, and crash history) could be supported by the focus V2I applications established by the department. The plan identifies generalized deployment locations along the freeway network and adjacent ramp intersections throughout the region.

Signal Controller/SPaT Broadcast Standardization

MDOT has undertaken update of the specifications for traffic signal controllers in part to standardize

controller equipment capable of generating SPaT messaging, either for current and future CV deployment. Standardizing this equipment will reduce the need to eventual need for upgrading the controllers to enable CV deployment, thereby reducing cost and complexity in the future. The new standards include provisioning of Ethernet ports, specific firmware requirements, and minimum processor specifications.

MAP Broadcast Standardization

Whereas a SPaT message broadcasts real-time traffic signal information relevant to all vehicles approaching and intersection, a MAP file is required for an individual vehicle to determine the relevant lane and phase information based on its position and approach direction. To develop a MAP file, detailed

survey-level data points are required to define lane alignments. In order to streamline the MAP development process, MDOT developed standard procedures for surveyors to collect and filter survey data for use in MAP file development. These procedures dramatically reduced the cost of this data collection and streamlined processes to be much more scalable for large-scale deployment.

Use of CV Data for Traffic Management Center Operations

CV data has tremendous potential to not only improve safety and mobility for motorists directly, but to enhance the ability of roadway operators to respond to incidents, re-route traffic, provide traveler information, and gather a wide range of data to support operations, maintenance and long-range planning. In response to this opportunity, MDOT commissioned a study to further explore how CV data could be operationalized within a traffic operations center environment. The study outlined a roadmap for what data would be most available and usable early in the deployment cycle, and recommended a pilot activity to incorporate some fleet data currently collected into the existing Advanced Traffic Management System (ATMS) in order to explore how it could improve operations.

Connected Vehicle Network Architecture Security Best Practices

Incorporation of RSUs, which communicate using next-generation Internet Protocol (IPv6), into the

state of Michigan's IT framework requires significant considerations in terms of IT networking and security implications. Working collaboratively with IT division under the Department of Management and Budget (DTMB), a strategy was developed to provide a scalable approach to accommodate RSU networking into the future. This included an overall network architecture, and security management best practices at the site, distribution network, and internet edge levels. This network architecture includes an embedded PC, referred to as a "Black Box" to handle some of the message translation, processing, and data push/pull functions which may ultimately be housed in the RSU itself or within a networked signal controller. Although this may ultimately be a transitional architecture, developing a networking and security protocol for this configuration was deemed a worst-case in that there is an intermediary device which must also be secured.

Due to the significant device expansion potential, the importance of developing a scalable Internet Protocol (IP) addressing scheme was identified at this early stage in order to minimize re-addressing of early deployment devices in a more mature system. As part of the procurement of the IPv6 internet circuit for connection to internet end points, MDOT negotiated for an IPv6 address block sufficient to address future system expansion. This allows for the development of an overall IP addressing scheme to be developed for CV devices which would enable systematic addressing over time, and limit the need for re-addressing devices in the future.

Outreach and Industry Leadership

Planet M

Planet M represents the collective mobility efforts across the state of Michigan around the technologies and services that enable people and goods to move around.

Working in partnership with automobile manufacturers and suppliers, universities, local agencies and a number of others in the public and private sectors, MDOT has set a vision for a connected

vehicle environment encompassing a large segment of southeast Michigan, centered along the freeway and surrounding arterial network in the metropolitan Detroit area. This corridor goes through the heart of Michigan's automotive and technology development area, and links to several other connected vehicle Pilot deployments, including the USDOT's test bed in Oakland County, a deployment in the City of Detroit, and the Safety Pilot Model Deployment/Ann Arbor Connected Vehicle Test Environment in Ann Arbor.

The connected vehicle environment is envisioned to encompass the four basic foundations of any connected vehicle system; supporting infrastructure, equipped vehicles and/or motorists, data and applications, and the communications network needed to support the system.

Automobili-D/North American International Auto Show

MDOT played a critical role in supporting the Michigan Economic Development Corporation (MEDC) and other partners in launching Automobili-D, a future-mobility themed conference and trade show coinciding with the 2017 North American International Auto Show (NAIAS) in Detroit. The event featured speaking sessions and expert panels discussing a wide range of mobility and transportation technology topics, along with exhibit space and a technology demonstration area. Exhibitors included OEMs and Tier 1 suppliers, academia, government agencies and test facilities.

2014 ITS World Congress

As a key partner in the 2014 ITS World Congress planning committee, MDOT was instrumental in the execution of the congress, including in particular the technology demonstrations coinciding with the event. MDOT led the technology demonstration planning, including site logistics, transportation/shuttling, vendor solicitation and coordination, and deployment of temporary CV infrastructure to support the demonstrations. Held on Belle Isle and in locations along the riverfront, the technology demonstrations were amongst the largest ever held in conjunction with the ITS World Congress, featuring a range of connected and automated driving scenarios.

Industry Organization Activities

MDOT is a leader among states through activities with a number of leading industry organizations, including the American Association of State Highway and Transportation Officials (AASHTO), the Transportation Research Board (TRB), the Intelligent Transportation Society of America (ITS America), and others. MDOT has contributed both financially and intellectually towards research, establishing policy

and best practices, and sharing lessons learned with the state DOT communities.

MDOT currently holds (currently or recently) leadership positions, or is a participant in the following major industry organizations/committees related to CAV:

National Leadership Positions - Chair

- *Chair*, AASHTO C/AV Executive Leadership Team
- *Chair*, AASHTO C/AV Working Group
- *Chair*, IOO (Infrastructure Owner/Operator) / OEM Collaborative Forum (developed through V2I Deployment Coalition)
- *Lead State*, Enterprise Pooled Fund Study (includes some studies on impacts of C/AV's).
- *Technical Working Group Chair*, AASHTO Special Committee on Wireless Communications Technologies (SCOWCT) - TWG2 Spectrum Management
- *Lead*, FHWA CV Integrating Mobile Observations (infrastructure/fleet vehicle deployment)
- *Lead*, FHWA EDC-4 CV Weather Savvy Roads
- *Lead*, FHWA Guidelines for Deploying Connected Vehicle-Enabled Weather Responsive Traffic Management
- *Chair*, NCHRP 20-102(02) Impacts of Regulations and Policies on CV and AV Technology Introduction in Transit Operations
- *Chair*, SAE Technical Committee: Vehicle-to-Infrastructure (V2I) Task Force
- *Chair*, TRB Regional TSMO Planning for Connected and Automated Vehicles

National Leadership Positions – Executive/Leadership Teams

- *Leadership Team/Executive Committee*, AASHTO Subcommittee on Transportation Systems Management and Operation
- *Executive Committee*, V2I Deployment Coalition

- *Voting Member and Planning Committee, AASHTO Subcommittee on TSM&O*

National Participation

- *Member, ITS America Leadership Circle (Past President)*
- *Core member, Connected Vehicle Pooled Fund Study (MDOT)*
- *Member, TRB Vehicle Highway Automation Committee*
- *Member, USDOT Connected Vehicle Reference Implementation Architecture workgroup*
- *Panel Member, NCHRP 20-102, Impacts of Connected and Automated Vehicles on local and state Transportation Agencies*
- *Panel Member, NCHRP 20-102 (01), Planning Considerations for Connected and Automated Vehicles*
- *Panel Member, NCHRP 20-102 (06), Pavement Markings for Machine Vision*
- *Committee Member, NCHRP 20-102(09) Providing Support CAV Impacts into Regional Transportation Planning and Modeling Tools*
- *Committee Member, AASHTO Special Committee on Wireless Communications Technologies (SCOWCT)*
- *Committee Member, NCHRP 20-102(03) Challenges to CV and AV Applications in Truck Freight Operations*
- *Committee Member, Society of Automotive Engineers (SAE) DSRC Technical Committee*
- *Member, TRB Intelligent Transportation Systems Committee*
- *Member, American Association of Motor Vehicle Administrators Automated Vehicle Licensing*

Smart Belt Coalition

MDOT has aligned with a multi-state coalition spanning Michigan, Ohio and Pennsylvania to pool

expertise and resources to advance CAV technologies in the region by providing a high-profile, high-impact and long-distance network of transportation innovations and connected automation. The consortium is comprised of the following entities by state:

- **Michigan:** MDOT, the University of Michigan, Michigan State University, and the American Center for Mobility.
- **Ohio:** The Ohio Turnpike and Infrastructure Commission, Ohio State University, and the Transportation Research Center.
- **Pennsylvania:** The Pennsylvania Department of Transportation, the Pennsylvania Turnpike Commission, and Carnegie Mellon University.

Ontario Ministry of Transportation (MTO) Partnership

The Ministry of Transportation of Ontario (MTO) and MDOT signed a Memorandum of Understanding (MOU) Regarding Automated Vehicle and Connected Vehicle (AV/CV) Testing and Development between Michigan and Ontario in August of 2017. The Governments of Michigan and Ontario wish to build on the existing an existing MOU regarding the automotive industries of Michigan and Ontario to further promote and foster sustainable growth and support innovation with regards to Automated Vehicle and Connected Vehicle (AV/CV) testing and development in Michigan and Ontario. To advance these goals, the Michigan Department of Transportation and Ontario Ministry of Transportation agree to: further increase collaboration related to AV/CV testing and deployment.

Texas Department of Transportation (TxDOT)/ Texas Transportation Institute (TTI) Partnership

The Texas Department of Transportation (TxDOT) and MDOT signed a Letter of Intent (LOI) titled "Infrastructure Advancement for the Transition of CAV" in February of 2017. The LOI intent is for the DOTs to collaborate for the deployment of smart, connected infrastructure to support the transition to connected automation and on-demand mobility services. MDOT and TxDOT believe that a collaborative and coordinated approach to connected vehicle and

infrastructure deployment is critical for the success of future transportation technology deployments. Texas and Michigan represent a wide range of differing geographic, population, roadway, and weather environments. The sharing of experiences for deploying technological solutions would demonstrate a collaborative approach to transportation solutions between geographically separate entities. Each entity can help the other to learn about the impacts of those variations on the deployment of these technologies.

Square One Education Network

MDOT supports the Square One Education Network in their mission of preparing K-12 students for careers in Science, Technology, Engineering and Mathematics (STEM) fields. The department has provided mentoring and technical guidance for the program specific to their V2X initiatives.

Community College Curriculum Support

MDOT has supported several area community colleges, including Wayne County Community College District, Washtenaw Community College, Macomb Community College, and others, in developing curriculums to support CAV technologies, including radio communications, IT/networking for CV, and others.

Four-Year University Curriculum Support

MDOT has supported several four-year universities, including Kettering University, Michigan Technological University, Wayne State University, and others, in developing curriculums to support CAV technologies.

Strategy Alignment & Opportunities

As presented in Section 6, MDOT is currently undertaking a wide range of initiatives to support the CAV program. This section explores the alignment of these current initiatives with the strategies outlined in Section 5, highlights gaps in the current initiative portfolio, and identifies additional tactical actions to help meet program goals.

Strategic Alignment and Gaps

Table 4 (next page) maps current initiatives against program strategies, in terms of which strategies each initiative helps to execute, and identifies strategies under which limited current tactical actions address.

As illustrated in the table, the following strategies were identified as having gaps in related tactical actions:

Critical Gap (no current initiatives):

- Strategy 5.1: Create mechanism for fostering, evaluating and selecting industry partnerships

Moderate Gap (current initiatives limited in number/scope):

- Strategy 1.1: Institutionalize CAV in related MDOT initiatives
- Strategy 2.1: Develop CV-related design and deployment standards
- Strategy 2.6: Identify and deploy infrastructure improvements to support automated vehicle deployment
- Strategy 3.2: Accelerate CV benefits through use of mobile technology
- Strategy 3.3: Accelerate CAV benefits through fleet deployments

These gaps reflect opportunities to further address key objectives of the program through additional tactical action.

Table 4: Alignment of Strategies and Tactical Actions

Critical Gap		Moderate Gap				STRATEGIES																	
CURRENT TACTICAL ACTIONS						1.1	1.2	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	4.1	4.2	5.1	5.2	5.3	5.4	5.5
Deployment Activities/Pilots																							
I-94 Road Weather Program										X		X	X	X			X						
M-53 SPaT/Transit Signal Priority Deployment												X		X			X						
I-275 Curve Speed Warning Deployment												X		X			X						
M-43 (Saginaw Highway) CV Deployment												X											
US-12Test Bed Deployment										X		X					X				X		
Mound Road Signal Phase andTiming (SPaT) Deployment												X		X			X						
Auburn HillsTest Bed Deployment												X		X			X						
I-75Test Bed Deployment										X		X	X				X						
Collision Avoidance and Mitigation System (CAMS)														X		X	X						
Weather-Responsive Traveler Information System (Wx-TINFO)										X	X			X	X	X							
Data Use, Analysis and Processing (DUAP) Program											X			X									
I-69Truck Platooning Test Support												X					X						
USDOTTest Bed Infrastructure Transition																	X						
Vehicle-Based Info Data Acquisition System (VIDAS) Program														X	X	X							
Programmatic Support Activities																							
Southeast Michigan V2I Deployment Plan									X														
Signal Controller/SPaT Broadcast Standardization								X						X									
MAP Broadcast Standardization								X						X									
Use of CV Data forTraffic Management Center Operations						X																	
CV Network Architecture Security Best Practices							X														X		
Mcity																	X	X			X		X
American Center for Mobility																	X	X			X		X
Outreach and Industry Leadership																							
Planet M																						X	
Automobili-D/North American International Auto Show																					X	X	
2014 ITS World Congress																						X	
Transportation Research Board (TRB) Activities																						X	X
AASHTO CV Leadership Activities																				X		X	X
Smart Belt Corridor Coalition																				X			
Ontario Ministry ofTransportation (MTO) Partnership																				X			
Texas DOT/Texas Transportation Institute (TTI) Partnership																				X			
Square One Education Network																		X					
Community College Curriculum Support																		X					
Four-Year University Curriculum Support																		X					

Strategy Reference:

- | | |
|---|---|
| 1.1 Institutionalize CAV in related MDOT initiatives | 3.3 Accelerate CAV benefits through fleet deployments |
| 1.2 Institutionalize IT and security for CAV | 4.1 Support industry research and testing in Michigan |
| 2.1 Develop CV-related design and deployment standards | 4.2 Play leadership role in developing Michigan's CAV workforce |
| 2.2 Develop plan for large-scale V2I deployment | 5.1 Create mechanism for fostering, evaluating and selecting future industry partnerships |
| 2.3 Lay foundation for CV in other infrastructure projects | 5.2 Support strategic partnering with peer organizations to advance state and/or regional positioning |
| 2.4 Develop foundational data management systems | 5.3 Partner with other state agencies to support CAV goals |
| 2.5 Deploy CV infrastructure to support other strategic initiatives | 5.4 Promote Michigan CAV activities through industry and public forums |
| 2.6 Identify and deploy infrastructure improvements to support automated vehicle deployment | 5.5 Play a leadership role in establishing national direction and best practices |
| 3.1 Support development of high-priority V2I applications | |
| 3.2 Accelerate CV benefits through use of mobile technology | |

MDOT ITS Program Office Tactical Actions

The following tactical actions are recommended to be undertaken by the ITS Program Office in order to supplement current initiatives to address critical and moderate strategic gaps:

Develop Partnering Evaluation Methodology and Tracking System

MDOT is fortunate to receive to a large number of industry partner requests to test/pilot technology deployments in the state. However, limitations in terms of staff and funding capacity require a process to enable more systematic tracking and evaluation of potential partnerships, based on value to the department, level of effort required, funding requirements, ease of implementation, and other factors. This initiative would result in the development of a methodology using qualitative and quantitative measures to evaluate and justify selection of partners, as well as a mechanism to track partnership requests and decision-making.

Strategies Addressed:

- **Strategy 5.1:** Create mechanism for fostering, evaluating and selecting industry partnerships

Update Cross-Departmental Impact Mapping

While CAV has received significant interest within MDOT, previous efforts to systematically identify how these technologies may impact units across the department are now outdated. Conducting an updated mapping exercise in conjunction with other unit leads will help to identify how CAV relates to each specific unit, what those needs and impacts may be, and to develop an outreach strategy to conduct targeted outreach and training activities with affected business units.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives

Develop Data Governance Plan/Policy

There will be a significant amount of data available within the CV ecosystem, which MDOT is already tapping into via the DUAP program and other data-related efforts. As proliferation of CV technologies and increased public awareness increase, both the volume of data and public data requests will escalate. To prepare for this, a formal data governance policy should be developed to address data privacy and security, procedures for storing data, sharing policies surrounding signal timing data, fulfillment of Freedom of Information Act (FOIA) requests, and other data-related policies.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives

Develop CV Design Procedures and Equipment Specifications

MDOT is proceeding with design and deployment of CV infrastructure in many locations throughout the state, as CV-related equipment is maturing. However, standards do not yet exist for what must be included in a CV design package, and roles are not yet fully defined between MDOT, designers, contractors and system integrators. This initiative would formalize the roles of these parties, develop a CV design guide which outlines design requirements and procedures, and formalize equipment specifications for common use across designers, building upon available national standards and best practices where available.

Strategies Addressed:

- **Strategy 2.1:** Develop CV-related design and deployment standards

Conduct Work Zone Mobile Application Pilot

MDOT completed a Concept of Operations (ConOps) for a connected work zone application using mobile technology in early 2016, and conducting foundational updates through 2016 to develop the back-end systems necessary to publish work zone-related

data to partners. To further this concept, MDOT will actively seek partnerships to leverage this data and formalize a pilot implementation.

Strategies Addressed:

- **Strategy 3.1:** Support development of high-priority V2I applications
- **Strategy 3.2:** Accelerate CV benefits through use of mobile technology

Prepare Fleet Deployment Plan

MDOT has pioneered data acquisition of maintenance fleet vehicles through the innovative VIDAS program, which includes a limited number of pilot vehicles. Developing a fleet deployment plan will map out expansion of this deployment to maximize department benefits, considering numbers, locations and functionality of vehicles.

Strategies Addressed:

- **Strategy 3.1:** Support development of high-priority V2I applications
- **Strategy 3.3:** Accelerate CAV benefits through fleet deployments

Conduct Additional Fleet Deployment

Upon completion of a fleet deployment plan, equipping additional MDOT and public partner fleet vehicles could further support acceleration of CAV benefits. This may include extension of the existing VIDAS system, as well as supporting targeted V2I applications.

Strategies Addressed:

- **Strategy 3.1:** Support development of high-priority V2I applications
- **Strategy 3.3:** Accelerate CAV benefits through fleet deployments

Conduct Staffing Audit and Organizational Evaluation

The role of the ITS Program Office is continually expanding with the demands of C/AV initiatives and the reach they have across the department. To meet this challenge, MDOT will evaluate the adequacy of existing staffing on current initiatives in order to supplement or re-prioritize resources. Further, the department will consider organizational changes to the ITS Program Office and other units to meet these increasing needs.

Strategies Addressed:

- **All**

Conduct Evaluation of Current/Prior Initiatives

In prioritizing future investments, it is important for the department to evaluate the effectiveness of prior investments in CAV research and development. MDOT therefore intends to perform an assessment on prior and on-going program actions to determine the degree to which objectives were met, the challenges of continued operation and maintenance, the condition of the system or investment relative to changes in technology, and the continued use case for the investment.

Strategies Addressed:

- **All**

Support Planet M Communications Strategy

Telling the story of CAV research and development initiatives happening in Michigan is critical to furthering those initiatives and improving outcomes and opportunities for the state. While MDOT is transitioning much of the communications strategy for Planet M to MEDC, MDOT will continue to be an active partner in developing, coordinating and executing that communications strategy to both the industry and the public.

Strategies Addressed:

- **Strategy 5.4:** Promote Michigan CAV activities through industry and public forums

National Research Initiatives

The department will continue to support national research initiatives, through activities of FHWA, AASHTO, TRB, and the CV Pooled Fund Study, amongst others, to study and consider the impact of CAVs on the transportation system and the required actions of MDOT to address them. The following research activities are of particular interest for further investment:

Evaluate Changes to Geometric Design of Roadways

There is grand speculation about how AVs could dramatically change how vehicles operate on the roadways and therefore what those roadways should look like in the future. Transportation agencies can allow the OEM's, the public, and elected officials define this future for them or they can be proactive in helping shape it.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives

Conduct Revenue Impact Study

It is currently generally assumed by many that AVs will operate best as electric vehicles. This is a possible future which will potentially have great impact on state transportation revenue due to reductions in fuel tax collections. In order for transportation agencies dependent of fuel tax to be well funding to meet the needs of the changing transportation environment because of CAVs there needs to be a engaged discussion on the issue of transportation revenue and how it relates to MDOTs to meet future needs.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives

Incorporating CAV in Planning and Forecasting Activities

CAV technologies and trends in mobility have the potential to profoundly change how we travel in the future. This in turn has an impact on how we plan long-term projects and forecast travel demand today. It is important for MDOT to continue to consider these impacts and new approaches to planning and forecasting in order to appropriately address these changing trends and technologies.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives

Study Required Changes to Roadway Signing/Striping/Traffic Controls to Accommodate CAVs

There is still significant debate over the potential need for updating or changes to signing, striping and traffic control devices to support safe AV operation on public roadways. MDOT supports additional research in this area to determine what changes may be advisable in terms of materials, application, and project programming priorities, to better accommodate the introduction of AVs.

Strategies Addressed:

- **Strategy 1.1:** Institutionalize CAV in related MDOT initiatives
- **Strategy 2.6:** Identify and deploy infrastructure improvements to support automated vehicle deployment

